

What is claimed is:

1 1. A method for concealing the effects of frame errors in frames
2 to be decoded by a decoder in providing synthesized speech, the
3 frames being provided over a communication channel to the
4 decoder, each frame providing parameters used by the decoder in
5 synthesizing speech, the method comprising the steps of:

6 a) determining whether a frame is a bad frame; and
7 b) providing a substitution for the parameters of the bad frame
8 based on an at least partly adaptive mean of the spectral
9 parameters of a predetermined number of the most recently
10 received good frames.

1 2. A method as in claim 1, further comprising the step of
2 determining whether the bad frame conveys stationary or non-
3 stationary speech, and wherein the step of providing a
4 substitution for the bad frame is performed in a way that depends
5 on whether the bad frame conveys stationary or non-stationary
6 speech.

1 3. A method as in claim 2, wherein in case of a bad frame
2 conveying stationary speech, the step of providing a substitution
3 for the bad frame is performed using a mean of parameters of a
4 predetermined number of the most recently received good frames.

1 4. A method as in claim 3, wherein in case of a bad frame
2 conveying stationary speech and in case a linear prediction (LP)
3 filter is being used, the step of providing a substitution for
4 the bad frame is performed according to the algorithm:

5 For $i = 0$ to $N-1$:

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6      adaptive_mean_LSF_vector(i)
7      =(past_LSF_good(i)(0)+past_LSF_good(i)(1)+...+past_LSF_good(i)(K-1))/K;
8      LSF_q1(i)
9      = $\alpha$ *past_LSF_good(i)(0)+(1- $\alpha$ )*adaptive_mean_LSF(i);
10     LSF_q2(i)=LSF_q1(i);

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wherein α is a predetermined parameter, wherein N is the order of the LP filter, wherein K is the adaptation length, wherein $LSF_q1(i)$ is the quantized LSF vector of the second subframe and $LSF_q2(i)$ is the quantized LSF vector of the fourth subframe, wherein $past_LSF_good(i)(0)$ is equal to the value of the quantity $LSF_q2(i-1)$ from the previous good frame, wherein $past_LSF_good(i)(n)$ is a component of the vector of LSF parameters from the $n+1^{th}$ previous good frame, and wherein $adaptive_mean_LSF(i)$ is the mean of the previous good LSF vectors.

5. A method as in claim 2, wherein in case of a bad frame conveying non-stationary speech, the step of providing a substitution for the bad frame is performed using at most a predetermined portion of a mean of parameters of a predetermined number of the most recently received good frames.

6. A method as in claim 2, wherein in case of a bad frame conveying non-stationary speech and in case a linear prediction (LP) filter is being used, the step of providing a substitution for the bad frame is performed according to the algorithm:

For $i = 0$ to $N-1$:

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6      partly_adaptive_mean_LSF(i)
7      =  $\beta$ *mean_LSF(i) + (1- $\beta$ )*adaptive_mean_LSF(i);
8      LSF_q1(i)
9      =  $\alpha$ *past_LSF_good(i)(0)+(1- $\alpha$ )*partly_adaptive_mean_LSF(i);

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10 $LSF_q2(i) = LSF_q1(i);$

11 wherein N is the order of the LP filter, wherein α and β are
12 predetermined parameters, wherein $LSF_q1(i)$ is the quantized LSF
13 vector of the second subframe and $LSF_q2(i)$ is the quantized LSF
14 vector of the fourth subframe, wherein $past_LSF_q(i)$ is the
15 value of $LSF_q2(i)$ from the previous good frame, wherein
16 $partly_adaptive_mean_LSF(i)$ is a combination of the adaptive
17 mean LSF vector and the average LSF vector, wherein
18 $adaptive_mean_LSF(i)$ is the mean of the last K good LSF vectors,
19 and wherein $mean_LSF(i)$ is a constant average LSF.

1 7. A method as in claim 1, further comprising the step of
2 determining whether the bad frame meets a predetermined
3 criterion, and if so, using the bad frame instead of substituting
4 for the bad frame.

1 8. A method as in claim 7, wherein the predetermined criterion
2 involves making one or more of four comparisons: an inter-frame
3 comparison, an intra-frame comparison, a two-point comparison,
4 and a single-point comparison.

1 9. A method for concealing the effects of frame errors in frames
2 to be decoded by a decoder in providing synthesized speech, the
3 frames being provided over a communication channel to the
4 decoder, each frame providing parameters used by the decoder in
5 synthesizing speech the method comprising the steps of:

- 6 a) determining whether a frame is a bad frame; and
7 b) providing a substitution for the parameters of the bad
8 frame, a substitution in which past immittance spectral
9 frequencies (ISFs) are shifted towards a partly adaptive mean
10 given by:

11 $ISF_q(i) = \alpha * past_ISF_q(i) + (1 - \alpha) * ISF_{mean}(i)$, for $i = 0..16$,

12 where

13 $\alpha = 0.9$,

14 $ISF_q(i)$ is the i^{th} component of the ISF vector for
15 a current frame,

16 $past_ISF_q(i)$ is the i^{th} component of the ISF vector
17 from the previous frame,

18 $ISF_{mean}(i)$ is the i^{th} component of the vector that
19 is a combination of the adaptive mean and the constant
20 predetermined mean ISF vectors, and is calculated using the
21 formula:

22 $ISF_{mean}(i) = \beta * ISF_{const_mean}(i) + (1 - \beta) * ISF_{adaptive_mean}(i)$, for $i = 0..16$,

23 where $\beta = 0.75$, where $ISF_{adaptive_mean}(i) = \frac{1}{3} \sum_{j=0}^2 past_ISF_q(j)$ and is
24 updated whenever BFI = 0 where BFI is a bad frame indicator,
25 and where $ISF_{const_mean}(i)$ is the i^{th} component of a vector
26 formed from a long-time average of ISF vectors.

1 10. An apparatus for concealing the effects of frame errors in
2 frames to be decoded by a decoder in providing synthesized
3 speech, the frames being provided over a communication channel to
4 the decoder, each frame providing parameters used by the decoder
5 in synthesizing speech, the apparatus comprising:

- 6 a) means for determining whether a frame is a bad frame; and
7 b) means for providing a substitution for the parameters of the
8 bad frame based on an at least partly adaptive mean of the
9 spectral parameters of a predetermined number of the most
10 recently received good frames.

1 11. An apparatus as in claim 10, further comprising means for
2 determining whether the bad frame conveys stationary or non-
3 stationary speech, and wherein the means for providing a
4 substitution for the bad frame performs the substitution in a way
5 that depends on whether the bad frame conveys stationary or non-
6 stationary speech.

1 12. An apparatus as in claim 11, wherein in case of a bad frame
2 conveying stationary speech, the means for providing a
3 substitution for the bad frame does so using a mean of parameters
4 of a predetermined number of the most recently received good
5 frames.

1 13. An apparatus as in claim 12, wherein in case of a bad frame
2 conveying stationary speech and in case a linear prediction (LP)
3 filter is being used, the means for providing a substitution for
4 the bad frame is operative according to the algorithm:

5 For $i = 0$ to $N-1$:

6 $\text{adaptive_mean_LSF_vector}(i)$

7 $= (\text{past_LSF_good}(i)(0) + \text{past_LSF_good}(i)(1) + \dots + \text{past_LSF_good}(i)(K-1)) / K;$

8 $\text{LSF_q1}(i)$

9 $= \alpha * \text{past_LSF_good}(i)(0) + (1 - \alpha) * \text{adaptive_mean_LSF}(i);$

10 $\text{LSF_q2}(i) = \text{LSF_q1}(i);$

11 wherein α is a predetermined parameter, wherein N is the order
12 of the LP filter, wherein K is the adaptation length, wherein
13 $\text{LSF_q1}(i)$ is the quantized LSF vector of the second subframe and
14 $\text{LSF_q2}(i)$ is the quantized LSF vector of the fourth subframe,
15 wherein $\text{past_LSF_good}(i)(0)$ is equal to the value of the
16 quantity $\text{LSF_q2}(i-1)$ from the previous good frame, wherein
17 $\text{past_LSF_good}(i)(n)$ is a component of the vector of LSF

18 parameters from the $n+1^{\text{th}}$ previous good frame, and wherein
19 $\text{adaptive_mean_LSF}(i)$ is the mean of the previous good LSF
20 vectors.

1 14. An apparatus as in claim 11, wherein in case of a bad frame
2 conveying non-stationary speech, the means for providing a
3 substitution for the bad frame does so using at most a
4 predetermined portion of a mean of parameters of a predetermined
5 number of the most recently received good frames.

1 15. An apparatus as in claim 11, wherein in case of a bad frame
2 conveying non-stationary speech and in case a linear prediction
3 (LP) filter is being used, the means for providing a substitution
4 for the bad frame is operative according to the algorithm:

5 For $i = 0$ to $N-1$:

6 $\text{partly_adaptive_mean_LSF}(i)$

7 $= \beta * \text{mean_LSF}(i) + (1-\beta) * \text{adaptive_mean_LSF}(i);$

8 $\text{LSF_q1}(i)$

9 $= \alpha * \text{past_LSF_good}(i)(0) + (1-\alpha) * \text{partly_adaptive_mean_LSF}(i);$

10 $\text{LSF_q2}(i) = \text{LSF_q1}(i);$

11 wherein N is the order of the LP filter, wherein α and β are
12 predetermined parameters, wherein $\text{LSF_q1}(i)$ is the quantized LSF
13 vector of the second subframe and $\text{LSF_q2}(i)$ is the quantized LSF
14 vector of the fourth subframe, wherein $\text{past_LSF_q}(i)$ is the
15 value of $\text{LSF_q2}(i)$ from the previous good frame, wherein
16 $\text{partly_adaptive_mean_LSF}(i)$ is a combination of the adaptive
17 mean LSF vector and the average LSF vector, wherein
18 $\text{adaptive_mean_LSF}(i)$ is the mean of the last K good LSF vectors,
19 and wherein $\text{mean_LSF}(i)$ is a constant average LSF.

1 16. An apparatus as in claim 10, further comprising means for

determining whether the bad frame meets a predetermined criterion, and if so, using the bad frame instead of substituting for the bad frame.

17. An apparatus as in claim 16, wherein the predetermined criterion involves making one or more of four comparisons: an inter-frame comparison, an intra-frame comparison, a two-point comparison, and a single-point comparison.

18. An apparatus for concealing the effects of frame errors in frames to be decoded by a decoder in providing synthesized speech, the frames being provided over a communication channel to the decoder, each frame providing parameters used by the decoder in synthesizing speech the apparatus comprising:

- a) means for determining whether a frame is a bad frame; and
- b) means for providing a substitution for the parameters of the bad frame, a substitution in which past immittance spectral frequencies (ISFs) are shifted towards a partly adaptive mean given by:

$$ISF_q(i) = \alpha * past_ISF_q(i) + (1 - \alpha) * ISF_{mean}(i), \text{ for } i = 0..16,$$

where

$$\alpha = 0.9,$$

$ISF_q(i)$ is the i^{th} component of the ISF vector for a current frame,

$past_ISF_q(i)$ is the i^{th} component of the ISF vector from the previous frame,

$ISF_{mean}(i)$ is the i^{th} component of the vector that is a combination of the adaptive mean and the constant

20 predetermined mean ISF vectors, and is calculated using the
21 formula:

22
$$ISF_{mean}(i) = \beta * ISF_{const_mean}(i) + (1 - \beta) * ISF_{adaptive_mean}(i) , \text{ for } i = 0..16 ,$$

23 where $\beta = 0.75$, where $ISF_{adaptive_mean}(i) = \frac{1}{3} \sum_{j=0}^2 past_ISF_j(i)$ and is
24 updated whenever BFI = 0 where BFI is a bad frame indicator,
25 and where $ISF_{const_mean}(i)$ is the i^{th} component of a vector
26 formed from a long-time average of ISF vectors.

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